

# Computing Systems in Engineering

*AN INTERNATIONAL JOURNAL*

Editors-in-Chief

AHMED K NOOR

BARRY H V TOPPING

**List of Contents and Author Index  
Volume 1, 1990**



**Pergamon Press**  
Oxford · New York · Seoul · Tokyo

# Computing Systems in Engineering

An  
International  
Journal

---

## Editors-in-Chief

**Professor Ahmed K. Noor**  
University of Virginia  
Mail Stop 210  
NASA Langley Research Center  
Hampton, VA 23665, U.S.A.  
Tel: 804 864 1978  
Fax: 804 864 8089

**Professor Barry H. V. Topping**  
Heriot-Watt University  
Riccarton  
Edinburgh EH14 4AS  
U.K.  
Tel: 031 449 5111  
Fax: 031 451 3170

---

## Editorial Advisory Board

**Dr P. J. Burns**  
Colorado State University,  
Fort Collins, CO, U.S.A.  
**Dr B. Buzbee**  
National Center for Atmospheric  
Research, Boulder, CO, U.S.A.  
**Dr D. L. Dwyer**  
NASA Langley Research Center,  
Hampton, VA, U.S.A.  
**Professor J. S. Gero**  
University of Sydney, Sydney, Australia  
**Dr M. Ginsberg**  
General Motors Technical Center,  
Warren, MI, U.S.A.  
**Professor D. E. Grierson**  
University of Waterloo,  
Waterloo, Ontario, Canada

**Dr O. G. Johnson**  
University of Houston,  
Houston, TX, U.S.A.  
**Professor P. W. Jowitt**  
Heriot-Watt University,  
Edinburgh, U.K.  
**Dr S. Karin**  
San Diego Supercomputer Center,  
San Diego, CA, U.S.A.  
**Professor D. J. Kuck**  
University of Illinois  
at Urbana-Champaign,  
Urbana, IL, U.S.A.  
**Dr W. R. Martin**  
University of Michigan,  
Ann Arbor, MI, U.S.A.

**Dr Y. Muraoka**  
Waseda University, Tokyo, Japan  
**Professor E. Ramm**  
Universität Stuttgart,  
Stuttgart 80, F.R.G.  
**Professor J. R. Rice**  
Purdue University,  
West Lafayette, IN, U.S.A.  
**Dr W. Schmidt**  
Dornier Luftfahrt GmbH,  
Friedrichshafen 1, F.R.G.  
**Dr V. Shankar**  
Rockwell International Science Center,  
Thousand Oaks, CA, U.S.A.  
**Professor D. J. Wallace**  
University of Edinburgh,  
Edinburgh, U.K.

---

## Aims & Scope

The objective of this journal is to communicate recent and projected advances in computational technology to practising engineers and research workers in this field.

The scope of the journal will include: innovative computational strategies and numerical algorithms for large-scale engineering problems; physical phenomena, in various engineering fields, uncovered by large-scale numerical simulations with a detailed description of the computational models, and the unique role of the new computing systems; effective visualization techniques; new computational technology (including new hardware, AI, knowledge-based and expert systems, new computing environment and user interface facilities with emphasis on their use in engineering applications); and impact of hardware on engineering education.

The journal will also encompass: survey papers on key application areas including future directions (e.g. state-of-the-art in computational fluid dynamics, computational structural dynamics, computational methods for device simulation and supercomputers in the automotive industry); summary papers on the activities of different supercomputer centres; listings of conferences, symposia and workshops; and book reviews.

---

### **Publishing, Subscription, and Advertising Offices**

Pergamon Press Inc., 395 Saw Mill River Road, Elmsford,  
NY 10623, U.S.A., or Pergamon Press plc, Headington Hill Hall,  
Oxford OX3 0BW, U.K.

**Back issues** of all previously published volumes, in both hard copy and on microform, are available direct from Pergamon Press offices.

Whilst every effort is made by the publishers and editorial board to see that no inaccurate or misleading data, opinion or statement appear in this journal, they wish to make it clear that the data and opinions appearing in the articles and advertisements herein are the sole responsibility of the contributor or advertiser concerned. Accordingly, the publishers, the editorial board and editors and their respective employees, officers and agents accept no responsibility or liability whatsoever for the consequences of any such inaccurate or misleading data, opinion or statement.

Copyright © 1991 Pergamon Press plc

It is a condition of publication that manuscripts submitted to this journal have not been published and will not be simultaneously submitted or published elsewhere. By submitting a manuscript the authors agree that the copyright for their article is transferred to the Publisher if and when the article is accepted for publication. However, assignment of copyright is not required from authors who

work for organizations which do not permit such assignment. The copyright covers the exclusive rights to reproduce and distribute the article including reprints, photographic reproductions, microform or any other reproductions of similar nature and translations. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means electronic, electrostatic, magnetic tape, mechanical, photocopying, recording or otherwise, without permission in writing from the copyright holder.

**Photocopying information for users in the U.S.A.** The Item-Fee Code for this publication indicates that authorization to photocopy items for internal or personal use is granted by the copyright holder for libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service provided the stated fee for copying beyond that permitted by Section 107 or 108 of the United States Copyright Law is paid. The appropriate remittance of \$3.00 per copy per article is paid directly to the Copyright Clearance Center Inc., 27 Congress Street, Salem, MA 01970.

**Permission for other use.** The copyright owner's consent does not extend to copying for general distribution for promotion, for creating new works, or for resale. Specific written permission must be obtained from the Publisher for such copying.

---

# CONTENTS OF VOLUME 1

## Vol. 1, No. 1

### i Editorial

P. E. Rubbert

1 The impact of supercomputers on CFD

V. Shankar, W. F. Hall,  
A. H. Mohammadian and  
S. Chakravarthy

7 Applications of Computational Fluid Dynamics-  
based methods to problems in computational  
science

A. K. Noor and S. L. Venneri

23 Advances and trends in computational structures  
technology

R. B. Haber

37 Visualization techniques for engineering mechanics

M. Giles and R. Haimes

51 Advanced interactive visualization for CFD

M. W. Berry

63 The use of matrix visualization in algorithmic  
design

P. J. Burns, J. D. Maltby and  
M. A. Christon

75 Large-scale surface to surface transport for photons  
and electrons via Monte Carlo

T. Nakata, N. Tanabe,  
N. Kajihara, S. Matsushita,  
H. Onozuka, Y. Asano and  
N. Koike

101 Cenju: a multiprocessor system for modular circuit  
simulation

H. Yamana, Y. Kusano, T. Yasue,  
J. Kohdate, T. Hagiwara and  
Y. Muraoka

111 Parallel processing system -Harray-

D. J. Wallace

131 Supercomputing with transputers

### *Book Reviews*

D. A. Bradley

143 Robotics in Civil Engineering, by M. Skibniewski

M. Papadrakakis

143 Structural Response Computations in Earthquake  
Engineering, by A. H. Barbat and J. M. Canet

### i Calendar of Events

### v Announcements

## COMPUTATIONAL TECHNOLOGY FOR FLIGHT VEHICLES

A. K. Noor and S. L. Venneri: Preface

v

*High-performance Computing and Parallel Computations*

S. F. Lundstrom: Supercomputing systems—a projection to 2000	145
H. T. Kung: Advances in multicomputers	153
R. F. Rashid and H. Tokuda: Mach: a system software kernel	163
J. Favenesi, A. Danial, J. Tombrello and J. Watson: Distributed finite element analysis using a transputer network	171
K. Gallivan, A. Sameh and Z. Zlatev: A parallel hybrid sparse linear system solver	183

*Multidisciplinary Computations*

C. J. Borland: A multidisciplinary approach to aeroelastic analysis	197
I. W. Tjatra, R. K. Kapania and B. Grossman: Transonic flutter analysis of aerodynamic surfaces in the presence of structural nonlinearities	211
I. Lee, H. Miura and M. K. Chargin: Static aeroelastic analysis of a three-dimensional oblique wing	219
K. W. Gwinn: Three-dimensional thermomechanical analyses of reentry vehicles	229
G. P. Guruswamy: ENSAERO—a multidisciplinary program for fluid/structural interaction studies of aerospace vehicles	237
R. Löhner: Three-dimensional fluid-structure interaction using a finite element solver and adaptive remeshing	257
J. Schuler and C. A. Felippa: Electromagnetic axisymmetric finite elements based on a gauged four-potential variational principle	273
I. U. Haq, R. V. Grandhi and R. K. Yedavalli: Robustness measures for integrated structural/control systems	285

*Advances in Grid Generation*

P. R. Eiseman: Interactive grid generation with control points	293
M. J. Berger and R. J. LeVeque: Stable boundary conditions for Cartesian grid calculations	305
R. E. Smith, E. L. Everton, K. J. Weilmuenster, M. R. Weise and N. Farr: Surface definition and grid generation about an Assured Crew Return Vehicle (ACRV) for space station freedom	313
M. E. M. Stewart: Multiblock mesh generation for multiple element airfoils with Euler solutions	325

*Visualization in Computational Fluid Dynamics and Other Space Activities*

V. Watson, P. P. Walatka, G. Bancroft, T. Plessel and F. Merritt: Visualization of fluid dynamics at NASA Ames	333
E. M. Murman, T. M. Becker and D. Darmofal: Computation and visualization of leading edge vortex flows	341
J. P. M. Hultquist: Interactive numerical flow visualization using stream surfaces	349
V. Gómez-Molinero, A. Escarda and J. Vilanova: VISTA: a new way in engineering animation	355

*Probabilistic Modeling and Boundary Layers*

T. A. Cruse, K. R. Rajagopal and J. B. Dias: Probabilistic structural analysis methodology and applications to advanced space propulsion system components	365
--	-----

A. Hamed and C. C. Chamis: Probabilistic modeling for simulation of aerodynamic uncertainties in propulsion systems	373
D. D. Knight: Numerical simulation of a three-dimensional shock wave-turbulent boundary layer interaction generated by a sharp fin at Mach 4	391
A. H. Nayfeh and J. A. Masad: Recent advances in secondary instabilities in boundary layers	401

#### *Numerical Simulations and Methodologies for Different Flow Regimes*

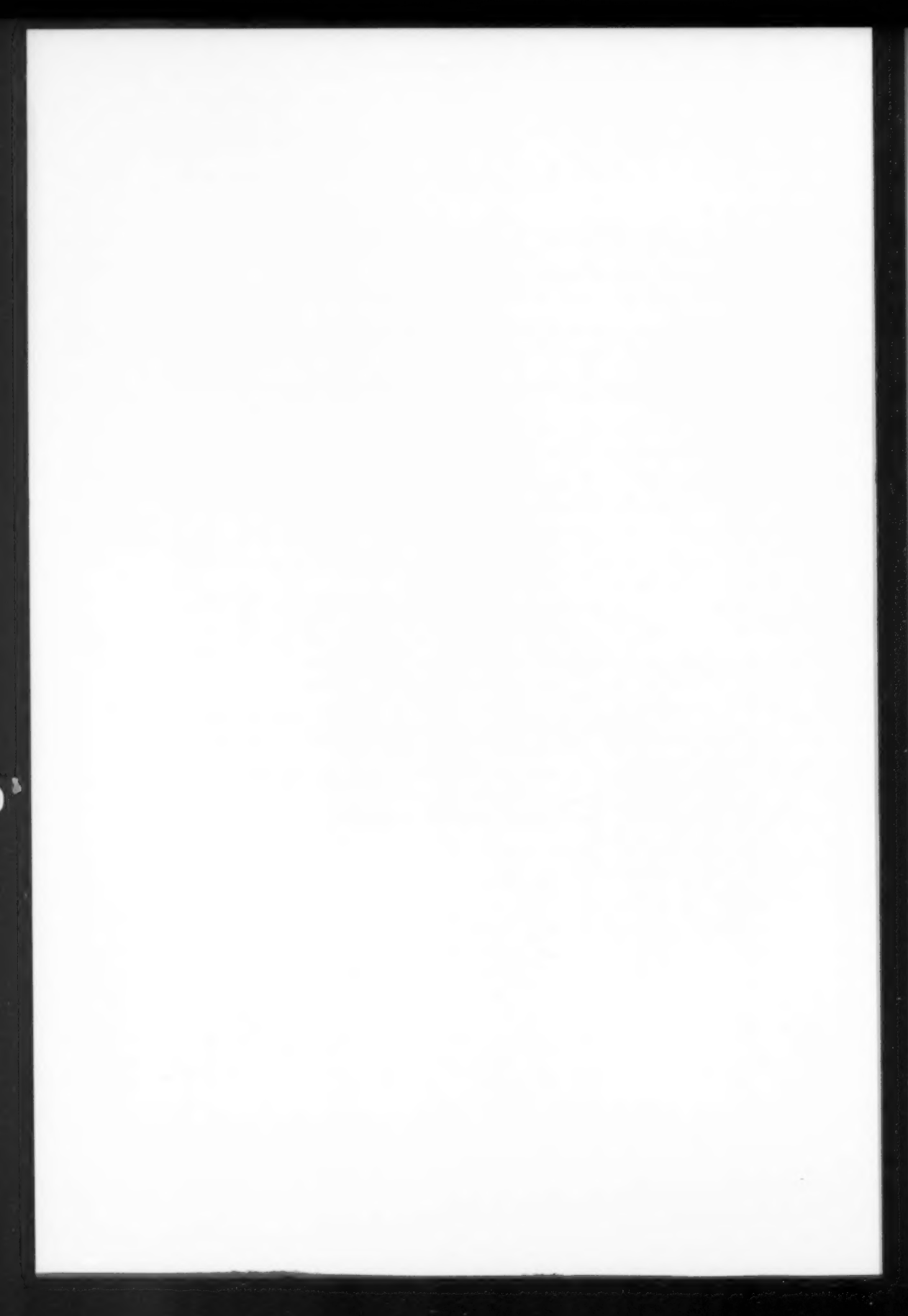
S. R. Chakravarthy and the Computational Fluid Dynamics Department: Computational aerodynamics methodology for the aerospace plane	415
D. Baganoff: Vectorization of a particle code used in the simulation of rarefied hypersonic flow	437
M. J. Siclari: Asymmetric separated flows over slender bodies at supersonic speeds	447
D. T. Mook and A. H. Nayfeh: Numerical simulations of dynamic/aerodynamic interactions	461
K. Chawla, W. R. Van Dalsem and K. V. Rao: Simulation of a delta wing with two jets in ground effect	483

#### *Computational Strategies and Adaptive Methods in Computational Fluid Dynamics*

F. Chalot, T. J. R. Hughes and F. Shakib: Symmetrization of conservation laws with entropy for high-temperature hypersonic computations	495
J. T. Oden, L. Demkowicz, T. Liszka and W. Rachowicz: $h$ - $p$ adaptive finite element methods for compressible and incompressible flows	523
S. Yoon and D. Kwak: Implicit methods for the Navier-Stokes equations	535
S. G. Rubin and P. K. Khosla: A review of reduced Navier-Stokes computations for compressible viscous flows	549
R. T. Biedron and J. L. Thomas: A generalized patched-grid algorithm with application to the F-18 forebody with actuated control strake	563

#### *Computational Strategies in Dynamics and Control*

S. K. Das, S. Utku and B. K. Wada: Use of reduced basis technique in the inverse dynamics of large space cranes	577
N. Venugopal, R. V. Grandhi, W. L. Hankey and P. J. Belcher: Combined energy management and calculus of variations approach for optimizing hypersonic vehicle trajectories	591
B. H. Aubert, J. F. Abel, J. Lu and J. S. Thorp: Effects of structural imperfections on constant-feedback-gain control of a spatial structure	601
E. Sacks: Automatic phase space analysis of dynamical systems	607



# AUTHOR INDEX

Vol. 1, Nos 1-4

- Abel, J. F. 601
- Asano, Y. 101
- Aubert, B. H. 601
- Baganoff, D. 437
- Bancroft, G. 333
- Becker, T. M. 341
- Belcher, P. J. 591
- Berger, M. J. 305
- Berry, M. W. 63
- Biedron, R. T. 563
- Borland, C. J. 197
- Bradley, D. A. 143
- Burns, P. J. 75
- Chakravarthy, S. R. 7, 415
- Chalot, F. 495
- Chamis, C. C. 373
- Chargin, M. K. 219
- Chawla, K. 483
- Christon, M. A. 75
- Cruse, T. A. 365
- Danial, A. 171
- Darmofal, D. 341
- Das, S. K. 577
- Demkowicz, L. 523
- Dias, J. B. 365
- Eiseman, P. R. 293
- Escarda, A. 355
- Everton, E. L. 313
- Farr, N. 313
- Favenesi, J. 171
- Felippa, C. A. 273
- Gallivan, K. 183
- Giles, M. 51
- Gómez-Molinero, V. 355
- Grandhi, R. V. 285, 591
- Grossman, B. 211
- Guruswamy, G. P. 237
- Gwinn, K. W. 229
- Haber, R. B. 37
- Hagiwara, T. 111
- Haimes, R. 51
- Hall, W. F. 7
- Hamed, A. 373
- Hankey, W. L. 591
- Haq, I. U. 285
- Hughes, T. J. R. 495
- Hultquist, J. P. M. 349
- Kajihara, N. 101
- Kapania, R. K. 211
- Khosla, P. K. 549
- Knight, D. D. 391
- Kohdate, J. 111
- Koike, N. 101
- Kung, H. T. 153
- Kusano, Y. 111
- Kwak, D. 535
- Lee, I. 219
- LeVeque, R. J. 305
- Liszka, T. 523
- Löhner, R. 257
- Lu, J. 601
- Lundstrom, S. F. 145
- Maltby, J. D. 75
- Masad, J. A. 401
- Matsushita, S. 101
- Merritt, F. 333
- Miura, H. 219
- Mohammadian, A. H. 7
- Mook, D. T. 461
- Muraoka, Y. 111
- Murman, E. M. 341
- Nakata, T. 101
- Nayfeh, A. H. 401, 461
- Noor, A. K. i(1), v(2-4), 23
- Oden, J. T. 523
- Onozuka, H. 101
- Papadrakakis, M. 143
- Plessel, T. 333
- Rachowicz, W. 523
- Rajagopal, K. R. 365
- Rao, K. V. 483
- Rashid, R. F. 163
- Rubbert, P. E. 1
- Rubin, S. G. 549
- Sacks, E. 607
- Sameh, A. 183
- Schuler, J. 273
- Shakib, F. 495
- Shankar, V. 7
- Siclari, M. J. 447
- Smith, R. E. 313
- Stewart, M. E. M. 325
- Tanabe, N. 101
- Thomas, J. L. 563
- Thorp, J. S. 601
- Tjatra, I. W. 211
- Tokuda, H. 163
- Tombrello, J. 171
- Topping, B. H. V. i(1)
- Utku, S. 577
- Van Dalsem, W. R. 483
- Venneri, S. L. v(2-4), 23
- Venugopal, N. 591
- Vilanova, J. 355
- Wada, B. K. 577
- Walatka, P. P. 333
- Wallace, D. J. 131
- Watson, J. 171
- Watson, V. 333
- Weilmuenster, K. J. 313
- Weise, M. R. 313
- Yamana, H. 111
- Yasue, T. 111
- Yedavalli, R. K. 285
- Yoon, S. 535
- Zlatev, Z. 183



## Notes for Contributors

### 1. Submission of papers

Manuscripts should be submitted (in triplicate) either to Professor Ahmed K. Noor, University of Virginia, Mail Stop 210, NASA Langley Research Center, Hampton, VA 23665, U.S.A. or to Professor Barry H. V. Topping, Department of Civil Engineering, Heriot-Watt University, Riccarton, Edinburgh EH14 4AS, U.K.

The journal publishes the following types of papers: research papers, short communications, tutorial articles and reviews. Only papers not previously published will be considered and, in the case of research papers and short communications, the material must be original. Submission of manuscripts also implies that the work has not been simultaneously submitted for publication elsewhere and authors must agree, once accepted by the journal, not to publish the paper elsewhere.

The language of the journal is English.

### 2. Style of manuscript

Manuscripts should not normally exceed 10,000 words (each figure should be counted as 250 words).

The manuscript should be organized in the following order: **Abstract** (not exceeding 200 words in length); **nomenclature** (a symbol list arranged in alphabetical order, with Greek symbols following the alphabetical listing; subscripts and superscripts should follow Greek symbols and should be identified with a heading); **main body of paper**; **acknowledgement** (where applicable); **references**; **appendices** (where applicable).

### 3. Typing procedure

Use good quality white paper. Type in double space throughout, on one side of the page only with adequate margins. All pages should be numbered consecutively. The title of the paper should be typed in capital letters and centred. After a two-line space type authors' names and affiliations in upper and lower case, also centred. Section headings should be typed in capitals and centred. Subsection headings should be typed in upper and lower case letters and be underlined.

### 4. Mathematical expressions

Mathematical symbols and formulae must be typed. Particular care should be exercised in identifying mathematical symbols used. All non-standard abbreviations or symbols should be defined when first mentioned. Distinction should be made between capital and lower case; between the letter O and zero (0); between the letter I and the number 1 and prime; between k and kappa. A vector will be printed in boldface and to indicate this the letter should be underscored with a single wavy line.

Standard symbols should be used whenever possible, preferably those recommended by the American Standards Association. Subscripts and superscripts must be readily apparent.

Equation numbers should appear in parenthesis and be numbered consecutively. All equation numbers must appear on the right-hand side of the page. The word "Equation(s)" appears in full at the beginning of sentences but should be abbreviated to "Eq.(s)" elsewhere.

Use the following sequence of parentheses: {}].

### 5. Units

Use Standard International (SI) units. Other units may be included in parenthesis.

### 6. Illustrations

Photographs, charts and diagrams are to be referred to as "Figure(s)" and should be numbered consecutively in the order in which they are referred. They should accompany the manuscript but should not be included in the manuscript pages.

Original line drawings or glossy prints (not photocopies), suitable for immediate reproduction, should be submitted. Drawings should be about twice the final size and the lettering must be clear and open and must also be large enough to be reduced by the same proportion. If this is not possible the lettering should be provided on an overlay.

A small number of illustrations in colour can be accepted for each issue of the journal, and will be printed within the text of the paper in which they appear. These illustrations should be kept to the minimum number necessary, and should occupy the minimum necessary area.

Transparencies (slides) should be supplied where possible, accompanied by a colour bromide print for each illustration. Authors should state clearly when they wish colour illustrations to be reproduced in colour.

Figure legends should be typed on a separate sheet and placed at the end of the manuscript. The amount of lettering on a drawing should be reduced as far as possible by transferring it to the legend.

The following standard symbols should be used on line drawings as they are easily available to the printer:  $\circ$   $\bullet$   $+$   $\Delta$   $\blacktriangle$

### 7. Tables

In the interest of economy and in order to avoid the introduction of errors, tables may be reproduced directly from the author's typescript and as such will be treated in the same way as line diagrams. Tables should be submitted in accordance with the following guidelines. (1) Page size should be 21 x 28 cm (or 8 1/2 x 11 inches). (2) Large or long tables should be typed on continuing sheets but identifying numbers should be placed on the upper right-hand corner of each sheet of tabular material. (3) Original top copies of the tables are required.

### 8. References

References to published literature should be quoted in the text by superior numbers, carefully checked, and grouped together at the end of the paper in numerical order. References should be complete. In listing them use the following style (do not use separate headings for journals, books, etc.).

O. McBryan, "Matrix and vector operations on hypercube parallel processors," *Parallel Computing* 5, 117-125 (1987).

K. Hwang and F. A. Briggs, *Computer Architecture and Parallel Processing*, McGraw-Hill, New York, 1984.

W. M. Gentleman and A. George, "Sparse matrix software," in *Sparse Matrix Computations* (edited by J. R. Bunch and D. J. Rose), pp. 243-261, Academic Press, New York, 1976.

J. Schwartz, "A taxonomic table of parallel computers based on 55 designs," *Ultracomputer Note No. 69*, Courant Institute, New York University, New York, 1983.

G. Amdahl, "The validity of the single-processor approach to achieving large-scale computing capabilities," *Proceedings of the American Federation of Information Processing Societies*, Washington, DC, 30, 1967, pp. 483-485.

### 9. Diskettes

Authors are encouraged to submit manuscripts on 5.25 or 3.5 inch IBM PC/AT-compatible diskettes as well as hard copy. To speed publication we use a standard text formatting program and to avoid incompatibilities request that documents be sent as plain ASCII files. Working files, such as those produced by "Word Perfect", should not be sent unless control characters used for formatting and mathematical expressions have been removed, usually achieved by printing to disk. The manuscript file(s) will be copied and the diskette(s) returned to the author.

### 10. Page proofs

Page proofs will be sent to the author (or the first-mentioned author in papers of multiple authorship, unless otherwise indicated) for checking. Corrections to the proofs must be restricted to printer's errors; any other changes to the text, in equations or grammar, may be charged to the author. Proofs should be returned within 48 hours of receipt.

No manuscripts or figures will be returned following publication unless a request for return is made when the manuscript is originally submitted.

### 11. Copyright forms

Because of recent changes in copyright laws the transfer of copyright from the author to the Publisher, previously implicit in the submission of a manuscript, must now be explicitly transferred to enable the Publisher to ensure maximum dissemination of the author's work. A copy of the Publishing Agreement to be used for *Computing Systems in Engineering* will be reproduced in each volume. Additional copies are available from the journal Editors or from the Publisher; or contributors may photocopy the agreement from the journal. A copy of this agreement, signed by the author, must accompany every article submitted for publication.

Written permission must be obtained from both author and publisher of any previously published material: text, tables, figures, etc. It is the author's responsibility to obtain this permission.

The Editors and Publisher cannot accept responsibility for the correctness of published programs or numerical results. The responsibility is that of the author who will have an opportunity to check the program and the results at proof stage.



